

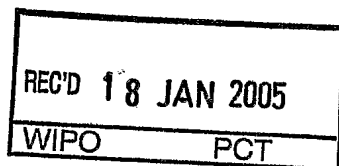


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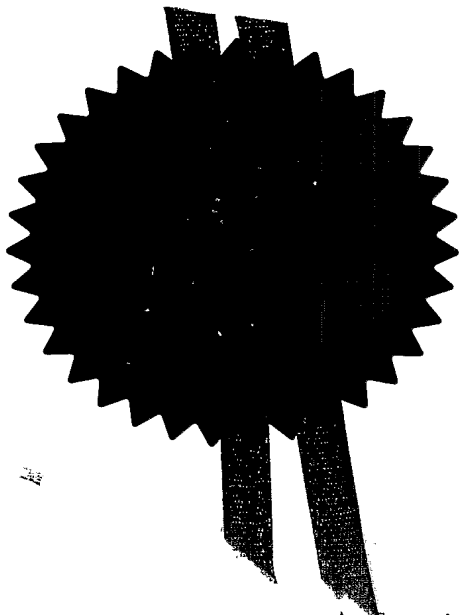
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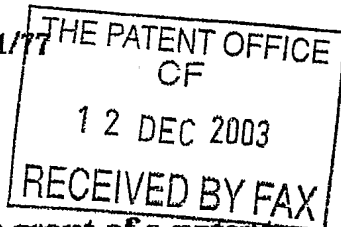
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CTV/P104374GB

2. Patent application number

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0328811.5

12 DEC 2003

3. Full name, address and postcode of the or of each applicant (underline all surnames)Antenova Limited
Far Field House
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Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

UK

4. Title of the invention

Antenna for mobile telephone handsets, PDAs and the like

5. Name of your agent (if you have one)

Harrison Goddard Foote

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

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14571001 7631310002

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Chris Vaughan

0113 233 0100

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DUPLICATE

ANTENNA FOR MOBILE TELEPHONE HANDSETS, PDAs AND THE LIKE

The present invention relates to antenna structures, including multi-band antenna structures, and techniques for the construction thereof, where an antenna is required
5 to be mounted on a printed wiring board (PWB) or printed circuit board (PCB) that has a full ground plane (i.e. metallised layer) on a side opposed to that on which the antenna is mounted.

It is often advantageous in the design of an electrically small antenna to remove part
10 of the ground plane on both sides of a PCB or through all the layers of a PWB as this can help to improve the bandwidth of the antenna. Unfortunately, many modern mobile telephone handsets have so many components to be fitted on the reverse side from the antenna (speakers, headphone sockets, USB connectors, display technology, etc.) that it is preferable not to remove the ground plane, either fully or partially. It is
15 therefore desirable to find a way of designing an antenna for mounting on a PCB/PWB, the antenna having the wide bandwidth required for modern mobile telephone handsets while still retaining a full ground plane beneath the antenna.

Dielectric antennas are antenna devices that radiate or receive radio waves at a
20 chosen frequency of transmission and reception, as used in for example in mobile telecommunications. In general, a dielectric antenna consists of a volume of a dielectric material disposed on or close to a grounded substrate, with energy being transferred to and from the dielectric material by way of monopole probes inserted into the dielectric material or by way of monopole aperture feeds provided in the
25 grounded substrate (an aperture feed is a discontinuity, generally rectangular in shape, although oval, oblong, trapezoidal or butterfly/bow tie shapes and combinations of these shapes may also be appropriate, provided in the grounded substrate where this is covered by the dielectric material. The aperture feed may be excited by a strip feed in the form of a microstrip transmission line, coplanar
30 waveguide, slotline or the like which is located on a side of the grounded substrate remote from the dielectric material). Direct connection to and excitation by a

microstrip transmission line is also possible, and in many cases is preferred as this generally forms a wide bandwidth antenna. Alternatively, dipole probes may be inserted into the dielectric material, in which case a grounded substrate is not required. By providing multiple feeds and exciting these sequentially or in various combinations, a continuously or incrementally steerable beam or beams may be formed, as discussed for example in the present applicant's co-pending US patent application serial number US 09/431,548 and the publication by KINGSLEY, S.P. and O'KEEFE, S.G., "Beam steering and monopulse processing of probe-fed dielectric resonator antennas", IEE Proceedings - Radar Sonar and Navigation, 146, 3, 121 - 125, 1999, the full contents of which are hereby incorporated into the present application by reference.

The frequency characteristics of a dielectric antenna depend, *inter alia*, upon the shape and size of the volume of dielectric material and also on the shape, size and position of the feeds thereto. It is to be appreciated that in a DRA, it is the dielectric material that resonates when excited by the feed. This is to be contrasted with a dielectrically loaded antenna (DLA), in which a traditional conductive radiating element is encased in a dielectric material that modifies the resonance characteristics of the radiating element. As a further distinction, a DLA has only a small displacement current flowing in the dielectric whereas a dielectric resonator antenna (DRA) or a high dielectric antenna (HDA) has a non-trivial displacement current.

The dielectric material of a dielectric antenna may take various forms, a common form having a cylindrical shape or half- or quarter-split cylindrical shape. The dielectric material can be made from several candidate materials including ceramic dielectrics, in particular low-loss ceramic dielectric materials.

Since the first systematic study of dielectric resonator antennas (DRAs) in 1983 [LONG, S.A., McALLISTER, M.W., and SHEN, L.C.: "The Resonant Cylindrical Dielectric Cavity Antenna", IEEE Transactions on Antennas and Propagation, AP-31, 1983, pp 406-412], interest has grown in their radiation patterns because of their high

- radiation efficiency, good match to most commonly used transmission lines and small physical size [MONGIA, R.K. and BHARTIA, P.: "Dielectric Resonator Antennas - A Review and General Design Relations for Resonant Frequency and Bandwidth", International Journal of Microwave and Millimetre-Wave Computer-Aided Engineering, 1994, 4, (3), pp 230-247]. A summary of some more recent developments can be found in PETOSA, A., ITTIPIBOON, A., ANTAR, Y.M.M., ROSCOE, D., and CUHACI, M.: "Recent advances in Dielectric-Resonator Antenna Technology", IEEE Antennas and Propagation Magazine, 1998, 40, (3), pp 35 - 48.
- 5
- 10 A variety of basic shapes have been found to act as good dielectric structures when mounted on or close to a ground plane (grounded substrate) and excited by an appropriate method. Perhaps the best known of these geometries are:
- Rectangle** [McALLISTER, M.W., LONG, S.A. and CONWAY G.L.:
15 "Rectangular Dielectric Resonator Antenna", Electronics Letters, 1983, 19, (6), pp 218-219].
- Triangle** [ITTIPIBOON, A., MONGIA, R.K., ANTAR, Y.M.M., BHARTIA, P.
and CUHACI, M.: "Aperture Fed Rectangular and Triangular Dielectric Resonators
20 for use as Magnetic Dipole Antennas", Electronics Letters, 1993, 29, (23), pp 2001-2002].
- Hemisphere** [LEUNG, K.W.: "Simple results for conformal-strip excited
hemispherical dielectric resonator antenna", Electronics Letters, 2000, 36, (11)].
25
- Cylinder** [LONG, S.A., McALLISTER, M.W., and SHEN, L.C.: "The Resonant
Cylindrical Dielectric Cavity Antenna", IEEE Transactions on Antennas and
Propagation, AP-31, 1983, pp 406-412].
- 30 **Half-split cylinder** (half a cylinder mounted vertically on a ground plane)
[MONGIA, R.K., ITTIPIBOON, A., ANTAR, Y.M.M., BHARTIA, P. and CUHACI,

M: "A Half-Split Cylindrical Dielectric Resonator Antenna Using Slot-Coupling", IEEE Microwave and guided Wave Letters, 1993, Vol. 3, No. 2, pp 38-39].

Some of these antenna designs have also been divided into sectors. For example, a cylindrical DRA can be halved [TAM, M.T.K. and MURCH, R.D.: "Half volume dielectric resonator antenna designs", Electronics Letters, 1997, 33, (23), pp 1914 - 1916]. However, dividing an antenna in half, or sectoring it further, does not change the basic geometry from cylindrical, rectangular, etc.

High dielectric antennas (HDAs) are similar to DRAs, but instead of having a full ground plane located under the dielectric element or pellet, HDAs generally have a smaller ground plane or no ground plane at all. However, as will be set out in more detail hereinbelow, the present applicant has found a novel technique for constructing an HDA with a full groundplane beneath the dielectric element. DRAs generally have a deep, well-defined resonant frequency, whereas HDAs tend to have a less well-defined response, but operate over a wider range of frequencies. HDAs can take the same variety of preferred shapes as DRAs. However, any arbitrary dielectric shape can be made to radiate and this can be useful when trying to design the antenna to be conformal to its casing.

20

In both DRAs and HDAs, the primary radiator is the dielectric material or pellet. In DLAs the primary radiator is a conductive component (e.g. a copper wire or the like) and the dielectric modifies the medium in which the antenna operates, and generally makes the antenna smaller. A simple way to make a printed monopole antenna is to extend a microstrip into a region where there is no grounded substrate on the other side of a dielectric substrate on which the dielectric element is mounted. Dielectrically excited antennas (DEAs) are similar to DLAs in that the primary radiator is a conductive component (such as a copper dipole or patch), but unlike DLAs they have no directly connected feed mechanism. DEAs are parasitic conducting antennas that are excited by a nearby dielectric or dielectric antenna

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having its own feed mechanism. There are advantages to this arrangement, as outlined in UK patent application no 0313890.6 of 16th June 2003.

For the avoidance of doubt, the expression "electrically-conductive antenna components" defines a traditional antenna component such as a patch antenna, slot antenna, monopole antenna, dipole antenna, planar inverted-L antenna (PILA), planar inverted-F antenna (PIFA) or any other antenna component that is not a DRA, HDA, DLA.

10 Additionally, for the purposes of the present application, the expression "dielectric antenna" is hereby defined as encompassing DRAs, HDAs and DLAs.

It is known from US 5,952,972 to provide a rectangular dielectric resonator antenna having a notch at a centre of its underside. The authors clearly believe the slot is the cause of the enhanced bandwidth together with a slab of high dielectric material inserted into the slot. However, this device might be viewed in a different way as a rectangular dielectric pellet elevated by 'legs' at each end. It is important to appreciate that the pellet rests on a groundplane which is on the top surface of a PCB, and that the pellet is fed by a slot in the groundplane surface. There is no feed taken up to the pellet and the pellet is not described as being metallised on any of its surfaces. The antenna of US 5,952,972 is therefore:

1. A DRA and not an HDA.
2. Not an elevated pellet clear of the groundplane.
3. Without an elevated feed.
- 25 4. Without a parasitic DEA component.
5. Not designed for inclusion in modern radiotelephone handsets.

According to a first aspect of the present invention, there is provided an antenna structure comprising a dielectric antenna component and a dielectric substrate with upper and lower surfaces and at least one groundplane, wherein the dielectric antenna component is elevated above the upper surface of the dielectric substrate such that

the dielectric antenna component does not directly contact the dielectric substrate or the groundplane, and wherein the dielectric antenna component is provided with a conductive direct feed structure.

- 5 The conductive direct feed structure advantageously extends from the upper surface of the dielectric substrate and directly contacts the dielectric antenna component. In preferred embodiments, the feed structure serves physically to support or elevate the dielectric antenna component above the upper surface of the dielectric substrate. However, in some embodiments the feed structure serves only to transfer energy to or
- 10 from the dielectric antenna component, the antenna component being physically supported or elevated by some other means, for example by being suspended from or attached to an additional substrate disposed above the upper surface of the dielectric substrate.
- 15 The conductive direct feed structure may be a conducting leg, a spring-loaded pin (a "Pogopin"), a metal strip or ribbon (preferably with sufficient rigidity to support the dielectric antenna component) or any other appropriate structure, and generally extends substantially perpendicularly from the upper surface of the dielectric substrate, although it may also be inclined relative thereto. It will be appreciated that
- 20 it is difficult to use a conventional printed microstrip feed, coplanar feed or other type of printed transmission line to feed the dielectric antenna component when elevated above the upper surface of the dielectric substrate.

- The conductive feed structure may contact an underside of the dielectric antenna component (i.e. the side or surface that generally faces the upper surface of the dielectric substrate), or may contact any of the other sides or surfaces of the dielectric antenna component. Advantageously, the side or surface of the dielectric antenna component that is contacted by the conductive feed structure may be metallised. One or more other sides or surfaces of the dielectric antenna component may also be
- 25 metallised.
- 30

Where the underside of the conductive antenna component is contacted by the conductive feed structure, it is particularly preferred that the conductive feed structure is in the form of a spring-loaded pin extending from the upper surface of the dielectric substrate.

5

An electrical connection between the conductive feed structure and the dielectric antenna component may be made by soldering or by mechanical pressure.

10 The dielectric antenna component or pellet may have any suitable shape. In some embodiments, the pellet is generally oblong or parallelepiped, optionally with one or more chamfered edges.

15 In embodiments where the antenna structure is intended to be enclosed within a mobile telephone or PDA (personal digital assistant) or laptop computer casing or the like, it may be advantageous for the dielectric antenna component or pellet, in particular but not exclusively upper and/or side surfaces thereof, to be shaped so as to be generally conformal with the casing, thereby making best use of the small amount of space available within the casing. In these embodiments, the dielectric antenna component may be physically supported from above by the casing or by any other
20 low permittivity antenna support structure. By "low permittivity" is meant a permittivity or dielectric constant significantly less than that of the dielectric material from which the dielectric antenna component is made, for example a permittivity not more than 10% of the permittivity of the dielectric antenna material itself.

25 It is to be appreciated that the antenna structure of embodiments of the present invention is not restricted to use with mobile telephone handsets and PDAs, but may find more general application. One particular area where these antenna structures may find utility is for use as wide bandwidth WLAN antennas where a full groundplane is needed, for example for use in laptop computers or access points.

30

The groundplane may be located on the upper or the lower surface or both surfaces of the dielectric substrate, or one or more groundplanes may be respectively sandwiched or embedded between two or more layers making up the dielectric substrate. In preferred embodiments, the groundplane extends across at least that part of the dielectric substrate that is located below the dielectric antenna component, and in preferred embodiments, extends across substantially the entire area of the dielectric substrate.

Because the dielectric antenna component is elevated above the upper surface of the dielectric substrate and does not directly contact this surface, it will be understood that a gap is thus defined between the dielectric antenna component and the upper surface of the dielectric substrate. In simple embodiments, this gap is an air gap. However, the gap may alternatively be filled with dielectric material or materials other than air, for example a spacer or the like made out of a dielectric material with a lower, preferably significantly lower dielectric constant than that of the material of the dielectric antenna component. In a particularly preferred embodiment, the spacer or the like is made of a dielectric material with a dielectric constant of no more than 10% of that of the dielectric antenna component itself. It is the presence of this air gap or dielectric spacer that helps to improve the bandwidth of the dielectric antenna component when energised by the conductive feed or by incoming radio/microwave signals.

In some embodiments, the antenna structure may include more than one elevated dielectric antenna component.

25

The dielectric antenna component may be configured as a DRA, an HDA and/or a DLA as a primary radiating structure. The primary radiating component may be used by itself, or may advantageously be provided with a secondary, parasitic antenna component that is located close to the primary radiating component and configured to operate at a significantly different frequency, thus providing dual band operation, or at a less significantly different frequency so as to provide higher bandwidth

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operation. A secondary (generally electrically conductive) antenna component driven parasitically by a primary dielectric antenna component may be considered to be a DEA.

- 5 Accordingly, embodiments of the present invention may combine a dielectric antenna structure of the first aspect of the invention in combination with a secondary antenna component configured to be parasitically driven by the dielectric antenna structure.

- 10 The secondary antenna component may be a patch antenna, slot antenna, monopole antenna, dipole antenna, planar inverted-L antenna, planar inverted-F antenna or any other type of electrically-conductive antenna component.

- 15 Furthermore, the secondary antenna component may be configured as a DLA, for example in the form of a PILA formed on or extending over a block or pellet of dielectric material.

- Alternatively, a secondary antenna component may be provided as discussed above, but configured such that the secondary antenna component is provided with its own feed and is driven separately from the dielectric antenna structure of the first aspect
20 of the present invention rather than being parasitically or solely parasitically driven thereby.

- According to a second aspect of the present invention, there is provided an antenna structure comprising a dielectric antenna component and a dielectric substrate with
25 upper and lower surfaces and at least one groundplane, wherein the dielectric antenna component is elevated above the upper surface of the dielectric substrate such that the dielectric antenna component does not directly contact the dielectric substrate or the groundplane, and wherein an additional antenna component with a conductive feed structure is provided on the dielectric substrate and configured parasitically to
30 drive the dielectric antenna component.

The additional antenna component may be a dielectric antenna component, or may be an electrically-conductive antenna component. In the second aspect of the present invention, the elevated dielectric antenna component is not provided with its own feed structure, but is parasitically driven by the additional antenna component.

5

As before, the dielectric antenna component and the additional antenna component may be configured to operate at significantly different frequencies so as to achieve dual band operation, or at similar frequencies so as to provide improved bandwidth.

10 In the first and second aspects of the present invention where both a driven and a parasitic antenna component is provided, one or other or both components may have series and parallel tuning components. Where a PILA or PIFA is included, either as a parasitically driven component or as a directly driven component, the PILA or PIFA may have tuned, switched or active short circuits.

15

For a better understanding of the present invention and to show how it may be carried into effect, reference shall now be made by way of example to the accompanying drawings, in which:

20 FIGURE 1 shows a first embodiment of the present invention;

FIGURE 2 shows a second embodiment of the present invention;

FIGURE 3 shows a third embodiment of the present invention;

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FIGURE 4 shows a fourth embodiment of the present invention; and

FIGURE 5 shows a plot of return loss of an antenna embodying the present invention.

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Figure 1 shows a dielectric substrate in the form of a printed circuit board (PCB) 1 having upper 3 and lower 4 surfaces and a conductive groundplane 2, 2' on each of the upper 3 and lower 4 surfaces. The PCB 1 shown in the Figure is suitable for incorporation into a mobile telephone handset (not shown), and the lower surface 4 will generally serve as a support for the various electronic components (not shown) of the mobile telephone. A ceramic dielectric pellet 5 is mounted on a conductive direct feed structure 6 in the form of a metal ribbon extending upwardly from the upper surface 3 of the PCB 1 in a corner thereof. In this way, the pellet 5 is raised or elevated over the PCB 1 and the groundplane 2 and does not directly contact either of these. The provision of an air gap between the pellet 5 and the groundplane 2 serves to improve the bandwidth of the pellet 5 when it is excited by the feed 6 so as to act as a dielectric antenna. The feed 6 is attached by way of soldering to a metallised inner side wall 7 of the pellet 5. The other end of the feed 6 is connected to a signal source (not shown).

In addition to the dielectric antenna formed by the pellet 5 and the feed 6, there is provided a planar inverted-L antenna (PILA) 8 including a leg 9 and an 'S'-shaped radiating section 10. The leg 9 is mounted on the upper surface 3 of the PCB 1 and provides a short circuit to the groundplane 2. The radiating section 10 extends over a top surface of the pellet 5. During operation, the pellet 5 is excited by way of the feed 6 and radiates as a dielectric antenna at a first predetermined frequency. The PILA 8 is parasitically driven by the pellet 5 and radiates at a second predetermined frequency, thus providing dual band operation. By adjusting the relative dispositions of the pellet 5 and the PILA 8, it is possible to adjust one or other or both of the first and second radiating frequencies.

Figure 2 shows an alternative embodiment in which the pellet 5 is mounted on a feed 6 in the form of a metallic ribbon, but this time attached to a metallised outer side wall 11 of the pellet 5. A PILA 8 with a short circuit leg 9 and radiating section 10 is also provided as in Figure 1, but here the PILA 8 includes a vertical capacitive flap 12 which faces the inner side wall 7 of the pellet 5. Adjusting the size and/or

disposition of the capacitive flap 12 allows the first and/or the second radiation frequencies to be adjusted. In comparison to the embodiment of Figure 1, the capacitive flap 12 of the embodiment of Figure 2 may allow a lower band frequency of the first and second frequencies to be lowered to a somewhat greater degree.

5

Figure 3 shows an alternative embodiment in which the pellet 5 is mounted on a feed in the form of a spring-loaded pin ("Pogopin") 13 which extends from the upper surface 3 of the PCB 1 and contacts a metallised underside of the pellet 5. This arrangement can have advantages in that the pellet 5 can be easily mounted on the pin 13 by way of mechanical pressure. A PILA 8 with a leg 9 and a radiating section 10 is provided as before, the radiating section 10 having a spiral configuration and passing over the upper surface of the pellet 5.

Figure 4 shows an alternative embodiment in which the pellet 5 is mounted not in the corner of the PCB 1, but about halfway along an edge of the PCB 1. The pellet 5 is elevated over the groundplane 2 as before, but this time with a spring-loaded metal strip 14 which acts as the feed 6. The spring-loaded metal strip 14 contacts an upper, metallised surface 14 of the pellet 5. In this embodiment, the PILA 8 has a double spiral configuration, one arm 15 of the radiating section 10 passing over the top of the pellet.

Figure 5 shows a typical return loss of an elevated-pellet handset antenna of the embodiment of the present invention shown in Figure 1. It can be seen that the return loss pattern allows quadruple band operation at 824MHz, 960MHz, 1710MHz and 1990MHz. The extra bandwidth in the upper band is a result of the pellet 5 being elevated above the groundplane 2.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

30

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. An antenna structure comprising a dielectric antenna component and a dielectric substrate with upper and lower surfaces and at least one groundplane,
5 wherein the dielectric antenna component is elevated above the upper surface of the dielectric substrate such that the dielectric antenna component does not directly contact the dielectric substrate or the groundplane, and wherein the dielectric antenna component is provided with a conductive direct feed structure.
- 10 2. An antenna structure as claimed in claim 1, wherein the conductive direct feed structure extends from the upper surface of the dielectric substrate and directly contacts the dielectric antenna component
3. An antenna structure as claimed in claim 2, wherein the conductive direct
15 feed structure physically supports the dielectric antenna component.
4. An antenna structure as claimed in claim 2, wherein the dielectric antenna component is physically supported or elevated above the groundplane or the dielectric substrate by a low permittivity antenna support structure.
- 20 5. An antenna structure as claimed in any preceding claim, wherein the conductive direct feed structure is a conducting leg, a spring-loaded pin, a metal strip or a metal ribbon.
- 25 6. An antenna structure as claimed in any preceding claim, wherein the conductive direct feed structure is directly attached to at least one side or surface of the dielectric antenna component.
7. An antenna structure as claimed in any one of claims 1 to 5, wherein at least
30 one side or surface of the dielectric antenna component is metallised, and wherein the

conductive direct feed structure is soldered or otherwise electrically connected to the metallised side or surface.

8. An antenna structure as claimed in claim 1, wherein the conductive direct
5 feed structure is a spring-loaded pin extending upwardly from the upper surface of the dielectric substrate, wherein the dielectric antenna component has a metallised underside that faces the upper surface of the dielectric substrate, and wherein a tip or tips of the spring loaded pin electrically contact the metallised underside.
- 10 9. An antenna structure as claimed in any preceding claim, wherein there is additionally provided at least one secondary, parasitic antenna component located close to the dielectric antenna component and configured to be parasitically excited by the dielectric antenna component and to radiate at a different frequency therefrom.
- 15 10. An antenna structure as claimed in claim 9, wherein the secondary, parasitic antenna component is an electrically conductive antenna component.
11. An antenna structure as claimed in claim 9 or 10, wherein the secondary, parasitic antenna component is a patch antenna, slot antenna, monopole antenna,
20 dipole antenna, planar inverted-L antenna, planar inverted-F antenna or the like.
12. An antenna structure as claimed in claim 9 or 10, wherein the secondary, parasitic antenna component is a dielectrically-loaded antenna component.
- 25 13. An antenna structure as claimed in claim 12, wherein the secondary, parasitic antenna component is configured as a planar inverted-L antenna with a radiating structure extending over a block or pellet of dielectric material such as a dielectric ceramic material.

14. An antenna structure as claimed in any one of claims 1 to 8, wherein there is additionally provided at least one secondary, driven antenna component located close to the dielectric antenna component and provided with its own feed.

5 15. ~~An antenna structure comprising a dielectric antenna component and a dielectric substrate with upper and lower surfaces and at least one groundplane, wherein the dielectric antenna component is elevated above the upper surface of the dielectric substrate such that the dielectric antenna component does not directly~~
10 ~~contact the dielectric substrate or the groundplane, and wherein an additional antenna component with a conductive feed structure is provided on the dielectric substrate and configured parasitically to drive the dielectric antenna component.~~

16. An antenna structure as claimed in claim 15, wherein the additional antenna component is a dielectric antenna.

15

17. An antenna structure as claimed in claim 15, wherein the additional antenna component is an electrically conductive antenna.

18. An antenna structure as claimed in any one of claims 15 to 17, wherein the
20 additional antenna component and the dielectric antenna component are configured so as to radiate at mutually different frequencies.

19. An antenna structure as claimed in any one of the preceding claims, wherein the dielectric antenna component is a high dielectric antenna (HDA).

25

20. An antenna structure as claimed in any one of the preceding claims, wherein the dielectric antenna component is a dielectric resonator antenna (DRA).

21. An antenna structure as claimed in any one of the preceding claims, wherein
30 the dielectric antenna component is a dielectrically loaded antenna (DLA).

22. An antenna structure as claimed in any preceding claim, wherein the groundplane is located on the upper surface of the dielectric substrate.

23. An antenna structure as claimed in any one of claims 1 to 21, wherein the
5 groundplane is located on the upper surface of the dielectric substrate.

24. An antenna structure as claimed in any one of claims 1 to 21, wherein a first groundplane is located on the upper surface of the dielectric substrate and a second groundplane is located on the lower surface of the dielectric substrate.
10

25. An antenna structure as claimed in any one of claims 1 to 24, wherein at least one groundplane is sandwiched between the upper and lower surfaces of the dielectric substrate.

15 26. An antenna structure as claimed in any preceding claim, wherein the groundplane extends across at least that part of the dielectric substrate that is located directly below the elevated dielectric antenna component.

27. An antenna structure as claimed in any preceding claim, wherein the
20 groundplane extends across substantially an entire area of the dielectric substrate.

28. An antenna structure as claimed in any preceding claim, wherein a gap defined between the elevated dielectric antenna component and the upper surface of the dielectric substrate is filled with a solid dielectric filler with a dielectric constant
25 less than that of the dielectric antenna component.

29. An antenna structure as claimed in claim 28, wherein the solid dielectric filler has a dielectric constant not more than 10% of that of the dielectric antenna component.
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30. An antenna structure as claimed in any preceding claim, wherein there is provided more than one elevated dielectric antenna component.

31. An antenna structure substantially as hereinbefore described with reference to
5 or as shown in the accompanying drawings.

ABSTRACT**ANTENNA FOR MOBILE TELEPHONE HANDSETS, PDAs AND THE LIKE**

5 The present invention relates to an antenna structure comprising a dielectric antenna component and a dielectric substrate with upper and lower surfaces and at least one groundplane, wherein the dielectric antenna component is elevated above the upper surface of the dielectric substrate such that the dielectric antenna component does not directly contact the dielectric substrate or the groundplane, and wherein the dielectric
10 antenna component is provided with a conductive direct feed structure. The dielectric antenna component is particularly preferably configured as a high dielectric antenna. Additional parasitic antenna components operating at different frequencies to the dielectric antenna component may also be provided, thus enabling multi-band operation. Elevating the dielectric antenna component so that it does not directly
15 contact the groundplane or the dielectric substrate significantly improves bandwidth of the dielectric antenna component.

Figure 1

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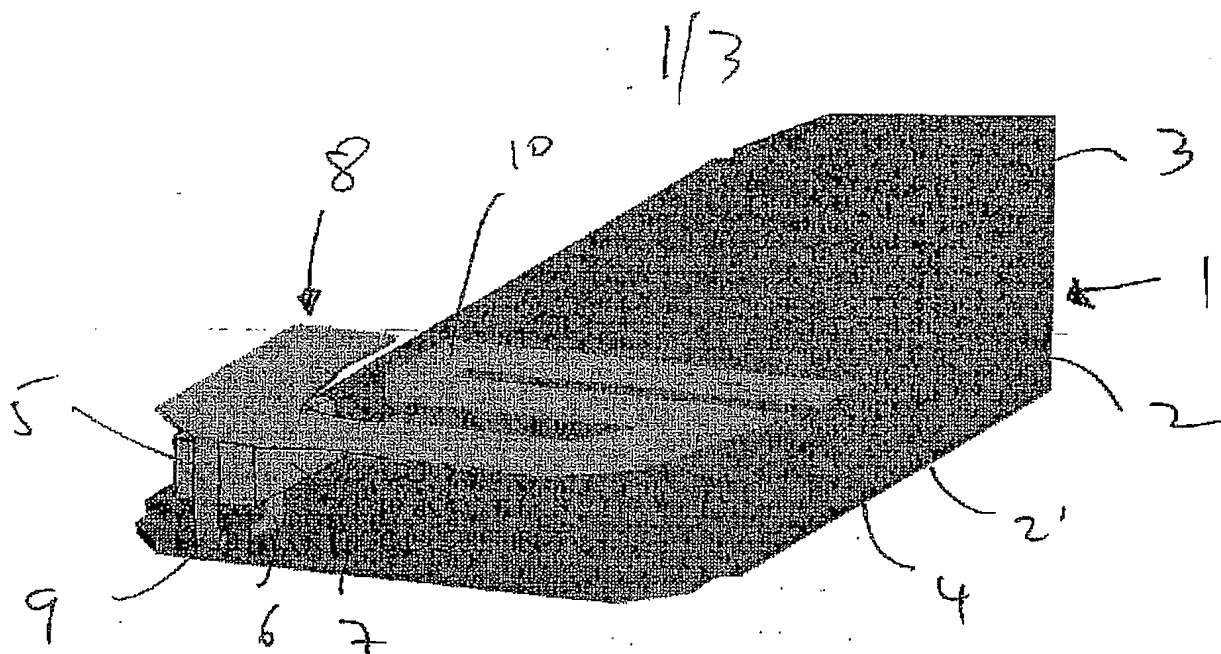


Figure 1. View of a mobile telephone antenna with an elevated ceramic pellet fed on the inner side wall and dielectrically exciting a PILA that passes over it.

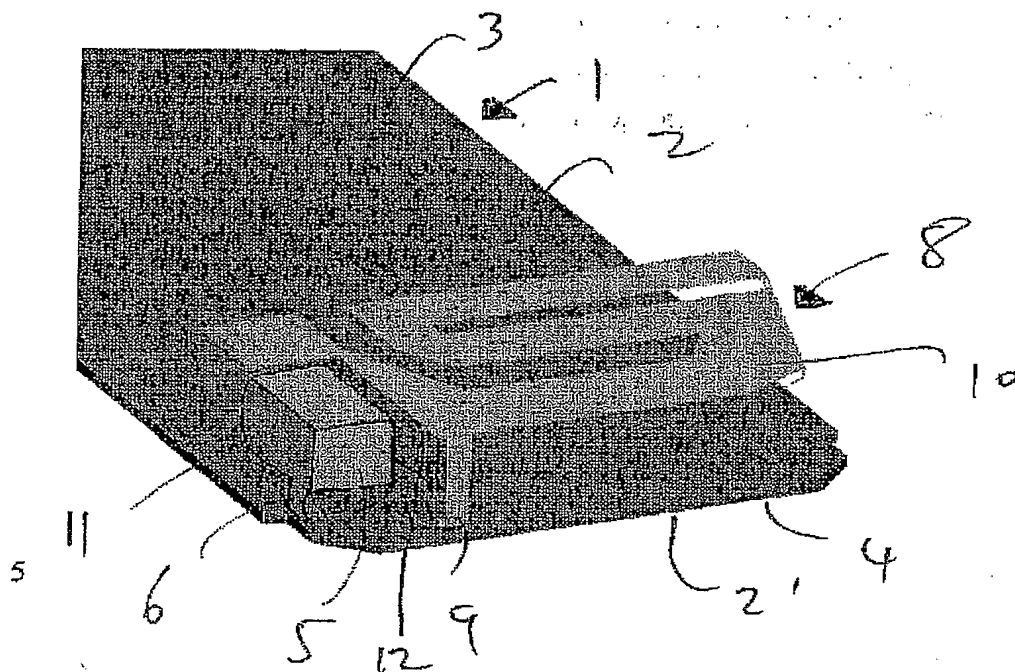


Figure 2. View of a mobile telephone antenna with an elevated ceramic pellet fed on the outer side wall and dielectrically exciting a PILA through a vertical capacitive flap.



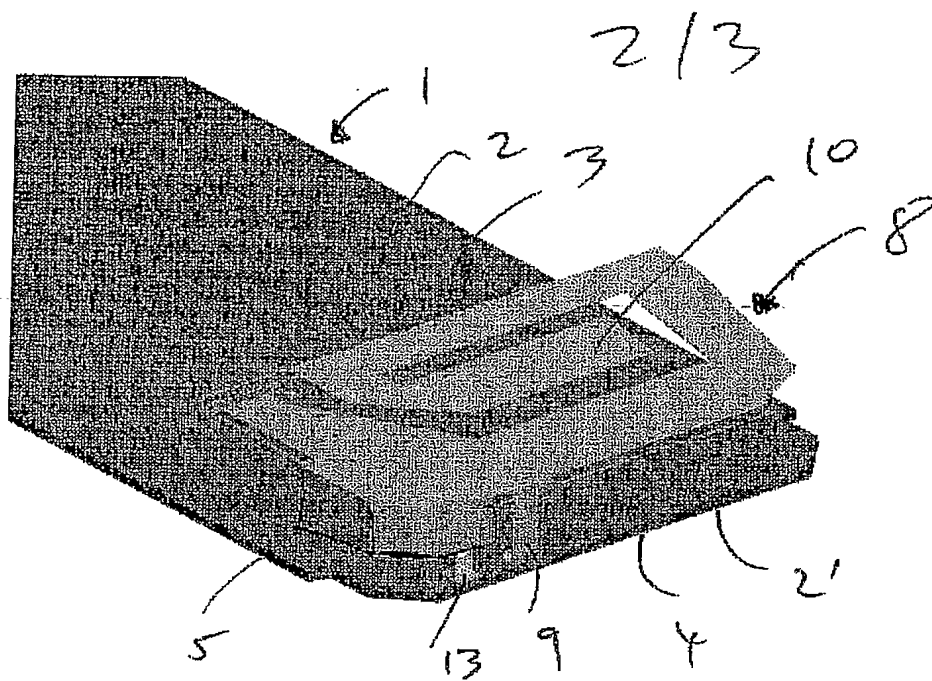


Figure 3. View of a mobile telephone antenna with an elevated ceramic pellet fed on the underside via a spring-loaded Pogopin.

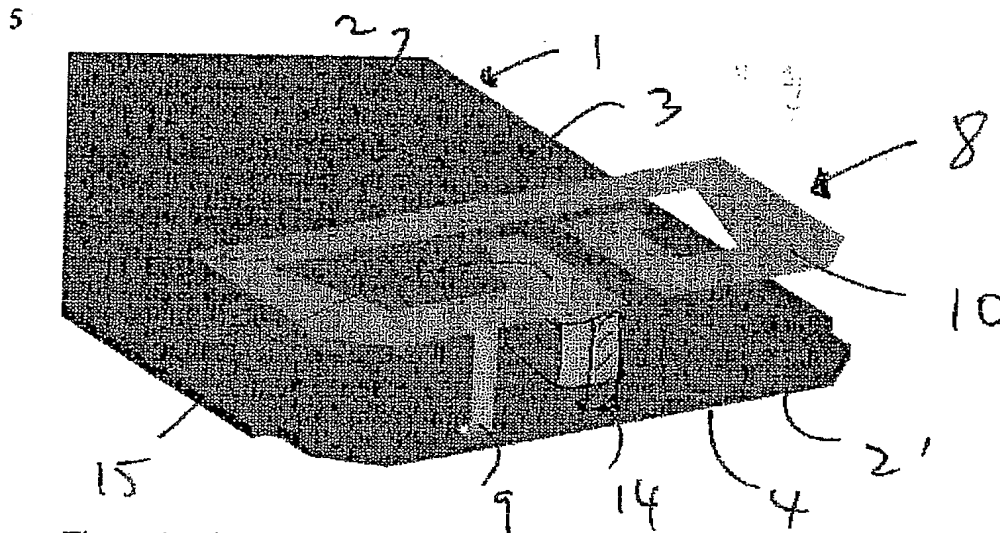


Figure 4. View of a mobile telephone antenna with an elevated ceramic pellet fed on the upper side via a spring-loaded metal strip.



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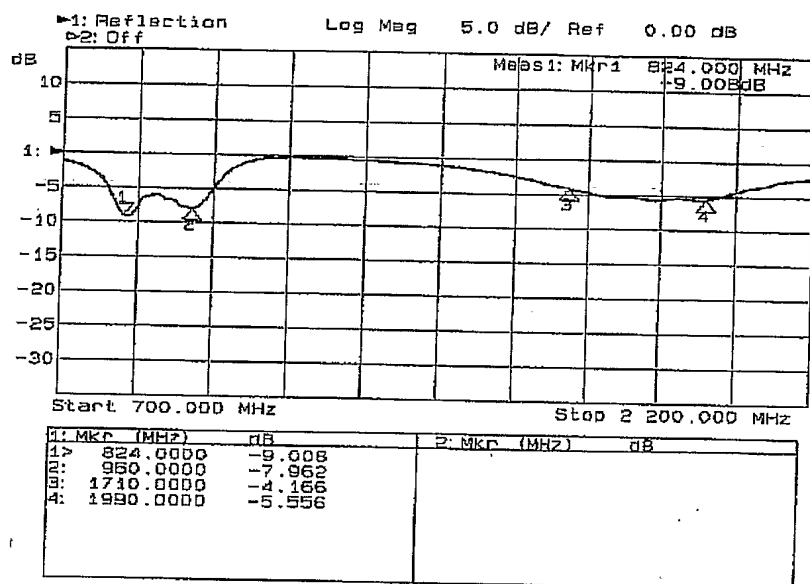


Figure 5. Typical return loss of an elevated-pellet handset antenna showing its suitability for development into a quadband design.

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